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## The Effect of Insecticide Applications on the Insect Fauna and Seed Yield of Alsike Clover in Southern Ontario[1]

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### Introduction

The work described here is an attempt to assess the effect of insecticides, particularly DDT, on the more prominent elements of the insect fauna of alsike clover *Trifolium hybridum* L., and on the yield of seed harvested. The decline in legume seed production, over a period of years, in districts which were once major seed producing areas is a familiar story in North America. For instance, Sorenson (1939) records that in 1925 Utah produced nearly 40 per cent of the total alfalfa seed in the United States. Five years later this state produced less than 4 per cent, the drop being largely the result of a decline in yield from an average of 6.4 to 1.2 bushels per acre. A similar history has been experienced in the production of alsike clover seed in Southern Ontario in the last twenty years. Haldimand County once produced heavy and profitable yields of over 5 bushels per acre but now yield is so poor and unprofitable that it is difficult even to find fields left for experimental work. No doubt many causes are at work in this reduction but there is good reason to believe that the successful establishment of specific insect pests, as a large and permanent part of the fauna, has been partly responsible in both these cases.

### Previous Work

There have been extensive studies on the possibility of substantially increasing seed yields in alfalfa by insecticidal treatment; many fewer in red clover and practically none at all in alsike clover. This bias merely reflects the relative importance of the three crops in North America.

Sorenson (1932) drew attention to the role of destructive insects in alfalfa seed production and subsequently (1936, 1939) identified the mirid bugs *Lygus hesperus* Knight and *L. elisus* Van Duzee as the most serious pests in Utah. Attempts were made (Sorenson, 1942) to effect control by cultural methods and by use of the older insecticides but without striking success. Stitt (1940) also recorded attempts to effect control by simultaneous harvesting of seed crops in a given area so that there would be no build up of bugs on late cut fields. With the introduction of DDT more intensive efforts were made to effect control by dusting or spraying. Cage and field trials were made by Hills (1944), Michelbacher et al (1945), Lieberman (1945, 1946), Packard (1945), Sorenson and Carlson (1946), and Smith and Michelbacher (1947). The results obtained were somewhat variable and in some experiments very heavy dosages of DDT were used. In addition to *Lygus* spp. *Adelphocoris lineolatus* Goeze and *A. rapidus* Say have also been recorded as damaging alfalfa seed crops. Here Medler and Scholl (1947) using 1½ to 2½ lbs. actual DDT per acre got significant increases in yield but recorded negative results using sabadilla. Considerable attention has also been given to the influence of spittlebugs and spittlebug nymphs on alfalfa particularly in Wisconsin. Fisher and Allen (1946) and Scholl and Medler (1947) record spittlebugs especially *Philaenus leucopthalmus* Linn. as being

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responsible for distorted growth, "bunchy top" condition and shrivelled seed. In tests against the spittle nymphs Chamberlin, Medler and O'Neill (1948) found chlordane more effective than DDT or benzene hexachloride. Chamberlin and Medler (1949) record that the effect of insecticide application was noticeable in sweep net catches as much as 19 days after application and Wilson (1949) records that DDT applications at the rate of 2 lbs. per acre were still effective after 1 to 4 weeks as indicated by catches of spittlebugs, tarnished plant bugs and leafhoppers. This lengthy residual effect is at variance with some of the results reported in this paper although plot size and arrangement was much the same. Unfortunately these investigators quote comparatively little data on the extensiveness and size of the insect collections. In red clover Schwardt, Newson and Norton (1947) found that increased yields of hay and forage were obtained by applying DDT and benzene hexachloride and mention a number of insects as being believed responsible for the injury observed. These include *Tychius griseus* Schaeffer, *Hypera meles* F., *Lygus oblineatus* (Say), *Sitona hispidula* (F.), *Philaenus leucopthalmus* Linn., *Empoasca fabae* (Harr.), *Hylastinus obscurus* (Marsh.) and aphids. The populations of the latter are noted as being significantly reduced by the applications but building up rapidly afterwards. Medler and Chamberlin (1948) obtained increased seed yields of Red and Ladino clovers spraying at the rate of 1 lb. actual DDT per acre when the clover was in partial bloom. A yield of 67 lbs. seed per acre was obtained compared with 38 lbs. on check plots. Insect infestation is recorded as being light but species identified

TABLE I.

SUMMARIZED RESULTS OF DATA OBTAINED FROM SPRAYING SMALL PLOTS AT KOHLER, HALDIMAND COUNTY, ON MAY 27, 1948. (SERIES 1).

| Insecticide treatment Rate of active material per acre. | Mean yield grams seed per 50 heads | Increase over check: grams | % increase over check |
|---|---|---|---|
| Benzene Hexachloride 2 lbs. | 0.94 | 0.32 | 51% |
| DDT 2 lbs. | 0.98 | 0.36 | 58% |
| DDT ½ lb. | 0.99 | 0.37 | 60% |
| DDT 1 lb. plus parathion ½ lb. | 1.15 | 0.53 | 85% |
| Check. No treatment | 0.62 | — | — |

STATISTICAL ANALYSIS

| Source of Variation | D.F. | Sum of squares | Mean square | F |
|---|---|---|---|---|
| Treatments | 4 | 1.1842 | 0.2961 | 4.7913** |
| Replications | 7 | 0.2535 | 0.0362 | 0.5858 |
| Error | 28 | 1.7302 | 0.0618 | |
| Total | 39 | 3.1679 | | |

For treatments, F.05 = 2.71 F.01 = 4.07
For replications, F.05 = 2.36 F.01 = 3.36

Necessary mean difference for treatments { 5% point } 0.2552 gram
{ 1% point } 0.3436 gram

as mainly responsible for the damage were *Lygus oblineatus*, *Adelphocoris lineolatus*, and *Hypera nigrirostris*. Pederson (1948) recommends either DDT or benzene hexachloride or mixtures of both at rates of about 1½ lbs. per acre, in one to three applications for increased seed yield in alfalfa and red clover; more data is recorded for the former crop.

**Preliminary Observations and Insecticidal Applications in 1948**

Work in 1948 was largely of a preliminary nature in which the insect fauna was studied and identified, and in which initial trials with insecticides were made to see whether seed yields could be increased at all, rather than produce a practical spraying schedule. Yields of seed were good in 1948, the best seen for years, but very low in 1949. It is therefore of interest to record the comparative results for the two years.

Table I shows the results obtained from spraying small plots, size 19 x 15 yards on the Kohler Airport field, Haldimand County. Wettable powder sprays were used. In this series five treatments (on four plots each) were applied from a small power machine at the rates of active material per acre shown, on May 27 before any appreciable bloom had appeared. Since the alsike was mixed with a great deal of volunteer red clover, yield was estimated by taking head samples (2 lots of 50 heads per plot). These give comparative figures but do not allow a comparison of expected seed yield per acre. Table II summarizes a second series of experiments on the same field using the newer insecticide parathion alone, but the results are less striking than in the first series. A third series of experiments

TABLE II.

SUMMARIZED RESULTS OF DATA OBTAINED FROM SPRAYING SMALL PLOTS AT KOHLER, HALDIMAND COUNTY, ON MAY 27, 1948. (SERIES II)

| Insecticide treatment. Rate of active material per acre | Mean yield grams seed per 50 heads | Increase over check: grams | % increase over check |
|---|---|---|---|
| Parathion 2 lbs. | 1.20 | 0.41 | 52% |
| Parathion 1 lb. | 0.96 | 0.17 | 22% |
| Parathion ½ lb. | 1.18 | 0.39 | 44% |
| Check. No treatment | 0.79 | — | — |

STATISTICAL ANALYSIS

| Source of Variation | D.F. | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 1.15 | 0.3833 | 4.6630** |
| Replications | 9 | 1.01 | 0.1122 | 1.3649 |
| Error | 27 | 2.22 | 0.0822 | |
| Total | 39 | 4.38 | | |

For treatments, F.05 = 2.96, F.01 = 4.60
For replications, F.05 = 2.25, F.01 = 3.14

Necessary mean difference for treatments { 5% point } 0.2626 gram
{ 1% point } 0.3548 gram

TABLE III.

SUMMARIZED RESULTS OF DATA OBTAINED FROM DUSTING PLOTS, SIZE ONE-THIRD OF AN ACRE, ON OTTERMAN FARM, HALDIMAND COUNTY, JUNE 4 TO JUNE 10, 1948.

| Insecticide treatment Rate of active material per acre | Mean yield lbs. seed acre | Increase over check: lbs. | % increase over check |
|---|---|---|---|
| Benzine Hexachloride 2½ lbs. | 245.78 | 48.44 | 25% |
| DDT 2½ lbs. | 288.32 | 90.98 | 46% |
| Check | 197.34 | — | — |

STATISTICAL ANALYSIS

| Source of Variation | D.F. | Sum of squares | Mean square | F. |
|---|---|---|---|---|
| Treatments | 2 | 66,323.79 | 33,161.89 | 11.5106** |
| Replications | 15 | 59,746.72 | 3,983.11 | 1.3825 |
| Error | 30 | 86,429.80 | 2,880.99 | |
| Total | 47 | 212,500.31 | — | |

For treatments, F.05 = 3.32, F.01 = 5.39
For replications, F.05 = 2.04, F.01 = 2.74

Necessary mean difference for treatments { 5% point } 38.72 lbs.–acre
{ 1% point } 52.20 lbs.–acre

were carried out on a much purer stand of alsike on the Otterman Farm, Haldimand County, and larger plots were laid out (50 x 30 yards, approximately one third of an acre). Here insecticides were applied as dusts, using a wheelbarrow duster, at the rather high rate of 2½ lbs. active material per acre. Applications had to be made over the period June 4- June 10 since high wind frequently interrupted the dusting. Yield was estimated by cutting, with a sickle, 4 one square yard quadrat samples per plot and threshing and weighing the seed obtained. Results obtained are shown in Table III. This was considered the most satisfactory series of experiments in 1948. It will be seen that benzene hexachloride gave a significant increase, and DDT a highly significant increase, in yield. In addition a fourth series of experiments was carried out on a limited area of very pure alsike at the College seed field, Guelph. Nine plots were laid out, each 1/20 acre in area, and a heavy application of dust (2 lbs. active material) was applied with a knapsack duster on June 11 and June 30. Two one-square-yard quadrat samples were cut from each plot to estimate yield. Results are shown in Table IV. Here the statistical examination shows a yield variation within the field itself so that increases at the 5 per cent point cannot be regarded as significant. However it will be seen that the increases obtained are significant at the 1 per cent point so that real increases resulting from insecticide application have occurred.

Since bees are essential for pollination in alsike clover objection may be taken to insecticides markedly toxic to them. After the 1948 work had commenced May and Synge (1948) reported that benzene hexachloride was highly toxic to bees but DDT comparatively safe; parathion also became suspect as a highly toxic bee poison, a supposition confirmed recently by Shaw and Butler (1949). Since

TABLE IV.

SUMMARIZED RESULTS OF DATA OBTAINED FROM DUSTING SMALL PLOTS ON COLLEGE SEED FIELD, GUELPH, JUNE 11 AND JUNE 30, 1948.

| Insecticide treatment Rate of active material per acre. | Mean yield lbs. seed -acre | Increase over check: lbs. | % increase over check |
|---|---|---|---|
| DDT 2 lbs. (twice) | 241.05 | 108.70 | 82% |
| Parathion 2 lbs. (twice) | 261.54 | 129.19 | 98% |
| Check | 132.35 | — | — |

STATISTICAL ANALYSIS

| Source of Variation | D.F. | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 2 | 57,858.28 | 28,929.14 | 18.130** |
| Replications | 5 | 37,377.41 | 7,475.48 | 4.6850* |
| Error | 10 | 15,956.18 | 1,595.62 | |
| Total | 17 | 111,191.87 | | |

For treatments, F.05 = 4.10, F.01 = 7.56
For replications, F.05 = 3.33, F.01 = 5.64

Necessary mean difference for treatments { 5% point } 51.42 lbs.-acre
{ 1% point } 73.10 lbs.-acre

neither of these two insecticides showed any improvement on DDT in increasing seed yield, it was decided to confine operation in 1949 to DDT and, with a view to producing a practical schedule, to use it at a low rate of application which might be economical and safe. The remainder of this paper is concerned with the work done in 1949.

**Arrangement of Plots in 1949**

In 1949 work was carried out on a volunteer stand of alsike, mixed with some red clover, at the Gifford Farm, Cayuga, Haldimand County and on a pure stand of alsike at the Brampton Seed Farm. A similar arrangement of plots was used at each site. Long narrow plots 121 yards long and 10 yards wide (¼ acre) or 8 yards wide (⅓ acre) were laid out side by side. In all 20 plots were marked off in 4 blocks of 5. Within each block the 5 randomly arranged plots received different treatments as follows:

| | CAYUGA | BRAMPTON |
|---|---|---|
| 1. Check—no application | | |
| 2. Single spray, bud stage | June 10-11 | May 30 |
| 3. Single spray, half bloom stage | June 21 | June 13 |
| 4. Single spray, full bloom stage | July 4 | June 16 |
| 5. Double spray, bud and full bloom stages | June 10-11, July 5 | May 30, June 16 |

Objection may be taken to the shape of these long narrow plots since they provide a large perimeter for insects from other plots, and elsewhere, to invade following the destruction of the plot fauna with insecticide. However they were of extremely convenient form for spraying with a tractor drawn power

TABLE V.

SUMMARIZED RESULTS OF DATA OBTAINED FROM SPRAYING ONE-FIFTH ACRE PLOT, AT RATE 1 LB. ACTUAL DDT PER ACRE, ON GIFFORD FARM, HALDIMAND COUNTY, 1949. FOR ACTUAL OPERATION DATES SEE TEXT.

| Treatments | Mean yield: grams seed per 100 heads | Increase over check: grams | % increase over check |
|---|---|---|---|
| Pre-blossom spray | 0.8654 | 0.4473 | 107% |
| Half-bloom spray | 0.6753 | 0.2572 | 62% |
| Full-bloom spray | 0.3903 | −0.0278 | −6.7% |
| Pre-& Full-bloom sprays | 0.8997 | 0.4816 | 115% |
| Check. No treatment | 0.4181 | — | — |

STATISTICAL ANALYSIS

| Source of Variation | D.F. | Sum of squares | Mean square | F. |
|---|---|---|---|---|
| Treatments | 4 | 3.6897 | 0.9224 | 18.1933** |
| Replications | 15 | 0.6096 | 0.0406 | |
| Error | 60 | 3.0448 | 0.0507 | |
| Total | 79 | 7.3441 | | |

For treatments, F.05 = 2.52, F.01 = 3.65

Necessary mean difference of treatments { 5% point } 0.1592 gram. { 1% point } 0.2117 gram.

machine, since their shape materially reduced the amount of turning which would have been necessary on more compact plots. This eliminated the need for turning "roads" between the plots which would have used up much of the already limited alsike acreage. Long narrow plots of approximately the same shape were used by Chamberlin and Medler (1949) and Wilson (1949) for the same reason, in insecticide trials on alfalfa, apparently without any difficulties.

**Insecticide Treatments**

DDT was applied as nearly as possible at the rate of 1 lb. actual DDT per acre (2 lbs. of 50 per cent wettable powder) in 100 gallons of water. Applications were made with a tractor drawn power sprayer (1¼ h.p. pump with maximum pressure of 350 lbs. from one nozzle) equipped with a specially made multi-nozzle boom, fifteen feet long, and adjustable in height to suit the stand of clover. This boom had a five yard wide coverage so that two runs were sufficient on each plot. The 100 gallon tank allowed the four similar plots (one to each block) to be sprayed with one filling. Applications were made in early morning or late afternoon or at a time when bees were not active in the fields. A rather high pressure machine was thought desirable in order to drive the DDT into the buds and opening flowers so as to place the insecticide deposit where it might be effective against seed weevils. Low power machines were not tested. Medler and Chamberlin (1949) have tested the more common low power spraying equipment against the alfalfa plant bug using a machine with a 20 ft. boom, 13

gallons per minute delivery at 30 lbs. pressure. They warn against using such a weed sprayer type in that some herbicidal residue is common in the tanks.

### Seed Yield in Relation to Insecticide Treatment

Seed yields in 1949 by contrast with those of 1948, were extremely poor. At Cayuga in 1948 a yield of 197 lbs. per acre was obtained on untreated check plots; in 1949 the figure was under 12 lbs. per acre. Insecticidal treatments did however give a percentage increase comparable with those of 1948 though the practical value of these increases was negligible. Table V shows the results obtained at Cayuga expressed in grams per 100 heads. Table VI shows the results of square yard quadrat samples taken from the same plots. The percentage increases obtained, except for the full bloom spray, are remarkably consistent in the two methods of estimating yield. The data summarized in these two tables indicate that the preblossom bud spray is most effective in increasing seed yield and that the double spraying—bud spray plus full bloom spray—does not give a significant increase over the first spray alone.

The yields obtained at Brampton were practically nil being of the order of 1 lb. per acre. The seed yield data from this site are not recorded here as the figures are so extremely low as to render any practical interpretation of doubtful value.

TABLE VI.

SUMMARIZED RESULTS OF DATA OBTAINED FROM SPRAYING ONE-FIFTH ACRE PLOTS, AT RATE OF 1 LB. ACTUAL DDT PER ACRE, ON GIFFORD FARM, HALDIMAND COUNTY, 1949. FOR ACTUAL OPERATION DATES SEE TEXT.

| Treatments | Mean yield: lbs. seed per acre | Increase over check: lbs. | % increase over check |
|---|---|---|---|
| Pre-blossom spray | 24.14 | 12.47 | 107% |
| Half-bloom spray | 18.54 | 6.87 | 59% |
| Full-bloom spray | 17.87 | 6.20 | 53% |
| Pre-& Full-bloom spray | 26.48 | 14.81 | 127% |
| Check. No treatment | 11.67 | — | — |

STATISTICAL ANALYSIS

| Source of Variation | D.F. | Sum of squares | Mean square | F. |
|---|---|---|---|---|
| Treatments | 4 | 2156.39 | 539.10 | 3.55 |
| Replications | 15 | 1529.51 | 101.97 | 0.67 |
| Error | 60 | 9123.64 | 152.06 | |
| Total | 79 | 12809.54 | | |

For treatments, F.05 = 2.52, F.01 = 3.65
For replications, F.05 = 1.83, F.01 = 2.36

Necessary mean differences for treatments { 5% point } 8.72 lbs.
{ 1% point } 11.60 lbs.

TABLE VII.

DDT RESIDUES. HALF BLOOM SPRAY APPLIED JUNE 13. (THE FIGURES UNDER JULY 20 ARE THE VALUES FOR HAY FOLLOWING HARVESTING). COLLEGE SEED FARM, BRAMPTON.

| | JUNE | | | | | | JULY | | |
|---|---|---|---|---|---|---|---|---|---|
| | 14 | 15 | 17 | 20 | 23 | 28 | 5 | 12 | 20 |
| Average Fresh Wt. square yard sample of alsike. Grams. | 253 | 245 | 241 | 208 | 225 | 230 | 212 | 175 | 41 |
| DDT mgms. per sq. yard alsike | 31 | 24 | 12 | 9.7 | 8.3 | 4.9 | 2.8 | 1.6 | 0.49 |
| DDT p.p.m. of alsike | 122 | 98 | 50 | 47 | 37 | 21 | 13 | 9 | 12 |

TABLE VIII.

DDT RESIDUES. DOUBLE SPRAY APPLIED MAY 30 AND JUNE 16. (THE FIGURES UNDER JULY 20 ARE THE VALUES FOR HAY FOLLOWING HARVESTING.) COLLEGE SEED FARM, BRAMPTON.

| | JUNE | | | | | | JULY | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 17 | 20 | 22 | 24 | 27 | 29 | 4 | 8 | 15 | 20 |
| Av. Fresh Wt. sq. yard sample of alsike grams. | 246 | 216 | 216 | 192 | 201 | 202 | 192 | 165 | 160 | 17.7 |
| DDT mgms. per sq. yd. alsike | 37 | 21 | 16 | 14 | 9.7 | 8.1 | 5.4 | 4.4 | 3.6 | 0.43 |
| DDT p.p.m. of alsike | 151 | 98 | 74 | 73 | 48 | 40 | 28 | 27 | 22 | 24 |

## DDT Residues

At Brampton, Dr. MacDougal of the Chemistry Department, Ontario Agricultural College, carried out measurements on the DDT residues detectable on alsike at increasing periods of time from the initial applications. Data were obtained for both the half bloom spray (applied June 13) and double spray (May 30 and June 16). Results are shown in Table VII and VIII. The DDT was sprayed at the rate of 1 lb. actual DDT per acre which is equal to 94 mg. per sq. yard but, since the alsike (from which recoveries of DDT alone were made) at this time covered only a portion of the ground, the figure of 31 mg. per sq. yard next day can be regarded as reasonably consistent.

DDT residue studies have been made on alfalfa by Smith, Fullmer and Messenger (1948) who conclude that "DDT is very persistent on alfalfa hay and seed chaff". The actual residue was found to be very variable, and dependent on conditions, but with an initial application of 1 lb. active material residues up to 20 p.p. million were obtained after weathering periods of 50 days or more. Smith, Hoskins, and Fullmer (1948) further showed that if alfalfa hay containing 7-8 p.p.m. of DDT is fed to dairy cattle, the milk produced after 2 or 3 days contained 2.3 to 3 p.p.m. Butter made from this milk contained 65 p.p.m. of DDT. This is rather at variance with the results Schwardt, Newsom and Norton (1947) who found that the DDT in the milk of dairy cattle, fed red

clover hay containing 10 p.p.m., was less than 1 p.p.m. Eden and Arant (1948) also studied DDT residues on alfalfa making up to 3 applications with dusts containing ½ to 1 lb. of actual DDT per acre. The highest residues they obtained were 162 p.p.m. (in the case of a three application treatment) immediately after harvesting; the lowest, recovered after 40 days storage, was 10 p.p.m. resulting from a single application of ½ lb. DDT per acre. The final residues tended to become equal regardless of the quantities originally applied.

**Insect Collections**

It is a general criticism of much work in this field that there is relatively little data on the insect populations, and their changes throughout the season on the treated, and on the check, plots. In some works considerable attention is given to the details of insecticide application, and to the seed yield finally obtained, but very little information is presented on the insects concerned. In this work attention was focussed on making very extensive collections on all plots from the time of the first application to the harvesting.

Insect collections were made on each plot throughout the season with a standard 12 inch sweepnet with a short (20 inch) handle. Each collection consisted of 30 full arm single sweeps and they were made on 10 plots daily (i.e. half the total plots) so that each plot was examined on alternate days. Insects were killed in the field, each collection funnelled into a separate bottle, and dried out on return to the laboratory. This sweeping method gives a somewhat quantitatively biased picture of the fauna but is the only feasible method for extensive collections. Active insects are often missed as are also many of the very small insects. In moist conditions aphids mash up in the net and it is difficult and laborious to count them; they were omitted from these records. These facts must be borne in mind when examining the data which apply therefore to the more obvious elements of the fauna. The totals of the various insects collected on the different plots at Cayuga is shown in Table IX whence it will be seen that two spittlebugs and two weevils make up nearly 90 per cent of the "sweepnet fauna". It is within these four that the key pest is to be expected. Though spittlebugs undoubtedly reduce the vegetative growth of alsike to some extent, no evidence is available to show that they were actually damaging seed. *Tychius griseus* Schaeffer and *T. picirostris* F. are two species of seed weevil once confused with each other and thought to be synonomous. Their habits are quite distinct however and they are easily differentiated in the field. *T. griseus* in my experience, was always found on the patches of volunteer red clover which contaminate the alsike; the species was never observed on the alsike itself. This weevil appeared earlier in the season and the insects were conspicuous perched on top of the red clover buds. *T. picirostris* appeared later and was not noticeable until the alsike was in flower when the weevils, decidedly darker than *T. griseus*, could be found hidden among the withered brown older florets at the base of the inflorescence. *T. picirostris* was never observed on red clover. At least in the region of Ontario studied, and with the population densities of 1948 and 1949 there appears to be a most distinct difference in plant host specificity for the two weevils. *T. picirostris* larvae, developing in alsike ovules, have been identified as destroying alsike seed by Arnott (1947) who is studying the biology of this species in detail as part of the programme of the Ontario Legume Research Committee; and in the present studies the writer did not observe any other insect specifically damaging alsike seeds. Of the others listed in Table IX even the ubiquitous pest *Lygus pratensis* is not present in sufficient numbers to be considered a danger while orthodox clover pests like *Hypera meles* F. and *H. nigrirostris* (F.) were rarely taken. (However, Mr. Morris Smith reports that

TABLE IX.

TOTAL CATCHES OF INSECTS ON DIFFERENT PLOTS AT CAYUGA.

| SPECIES | PLOT TREATMENTS | | | | | SPECIES TOTALS |
|---|---|---|---|---|---|---|
| | Checks | Bud spray | Half bloom spray | Full bloom spray | Double spray | |
| Philaenus leucopthalmus L. var pallidus | 4270 | 4233 | 3665 | 3702 | 3102 | 18,972 |
| P. leucopthalmus L. var. spumarius | 3652 | 2953 | 2884 | 3027 | 2312 | 14,828 |
| Tychius picirostris F. | 2346 | 1858 | 1825 | 2406 | 1514 | 9,949 |
| T. griseus Schaeffer | 1881 | 1755 | 1924 | 1805 | 1385 | 8,750 |
| Lygus pratensis L. | 369 | 340 | 328 | 310 | 362 | 1,709 |
| Zenoborus commissuralis Reuter | 365 | 287 | 314 | 331 | 237 | 1,534 |
| Oliarus humilis Say | 152 | 189 | 149 | 176 | 264 | 930 |
| Philaenus leucopthalmus L. var. marginellus | 198 | 189 | 146 | 148 | 129 | 810 |
| Nabis ferus L. | 133 | 140 | 126 | 125 | 109 | 633 |
| Miris dolobratus | 151 | 62 | 90 | 171 | 69 | 543 |
| Systena frontalis F. | 154 | 109 | 89 | 7 | 16 | 375 |
| Mesogramma marginata Say | 56 | 52 | 61 | 56 | 52 | 277 |
| Euschistus variolarus P. de B. | 40 | 37 | 27 | 24 | 36 | 164 |
| Adelphocaris rapidus Say | 32 | 31 | 41 | 26 | 29 | 159 |
| Campylenchia latipes (Say) | 43 | 27 | 20 | 21 | 13 | 124 |
| Coccinella perplexa | 13 | 22 | 13 | 18 | 20 | 86 |
| Hypera meles F. | 12 | 22 | 18 | 14 | 11 | 77 |
| H. nigrirostris (F.) | 8 | 23 | 10 | 13 | 12 | 66 |
| Cosmopepla carnifex F. | 18 | 15 | 1 | 8 | 7 | 49 |
| N. subcoleopterus Kirby | 12 | 9 | 4 | 9 | 5 | 39 |
| Hippodamia parenthesis Say | 4 | 13 | 9 | 4 | 8 | 38 |
| Lucidota sp. | 1 | 2 | 1 | 4 | 1 | 9 |
| Diabrotica 12 punctata F. | 0 | 3 | 0 | 0 | 2 | 5 |
| Zygrogramma suturalis F. | 0 | 0 | 0 | 1 | 0 | 1 |
| Plot Totals | 13,910 | 12,371 | 11,745 | 12,406 | 9,695 | |
| | | | | | Grand Total | 60,127 |

the latter two species are numerous in alsike clover in Simcoe county where *T. picirostris* is absent or rare). A beetle not found at Cayuga in 1949 but common at Guelph in 1948 was the nitidulid beetle, *Meligethes mutatis* Harold,

observed eating the pollen of alsike flowers. It is therefore, possibly, a potential danger to alsike seed production. A closely related species *M. aeneus* (F.) has been shown to be responsible for reduction of pollination in the musk melon (Li Peng Fi and Larson, 1949).

**DDT and Reduction of Insect Populations**

Table IX shows that the overall reductions of insect populations as a result of the DDT treatments was slight. In Table X the percentage reduction in total

TABLE X.

SEED YIELD INCREASE AND INSECT REDUCTION, CAYUGA, 1949.

| | Seed Yield % Increase over check | | Total Seasonal Insect Reduction % Reduction over check | |
|---|---|---|---|---|
| | Head counts | Quadrats | All insects | T. picirostris |
| Bud spray | 107% | 107% | 11.1% | 21.0% |
| Half bloom spray | 62% | 59% | 15.6% | 22.0% |
| Full bloom spray | −6.7% | 53% | 10.8% | −2.6% |
| Double spray (bud plus full bloom) | 115% | 127% | 30.5% | 35.6% |

season population of (a) all insects and (b) *T. picirostris* alone, are compared with the increases in seed yield estimated by the two methods of harvesting. The increases in seed yield are much more conspicuous. However since it appears unlikely that any insect compares with *T. picirostris* in being of prime importance in seed destruction, correct timing of applications to reduce this population, at a critical moment in relation to seed development is of the greatest importance. A temporary reduction in numbers at such a time is probably of more importance than an overall seasonal reduction. A better picture of the changes throughout the season is shown graphically. Fig. 1 shows the catch of the various species of insects on the untreated check plots; the dominating position of the four insects mentioned earlier is clearly shown here. Fig. 2 shows the effect of the half bloom spray on all elements of the fauna. Though the effect is marked the rapid recovery of populations in a matter of 5 to 10 days is noteworthy. It must be supposed that most of this recovery is the result of the pressure of inward migration of insects from other parts of the field to fill up the gap resulting from treatment. A more detailed illustration of the five different plot treatments on the numbers of *Tychius picirostris* is shown in Fig. 3. The applications of DDT on different dates are shown in the figure by arrow stakes. In each case, the application causes a marked reduction in numbers for a few days following the spraying. The effect is most noticeable in the half-bloom spray of June 21 (Fig. 3c) which completely eliminates the peak in weevil numbers occurring 3 or 4 days later on the check plots (X peak in Fig. 3a) and noticeable on other plots. Some 8 days later however, the weevil populations are back to numbers (Y peak in Fig. 3c) comparable with those on the check plots. It should be remembered however, that the bud spray of June 11 (Fig. 3b) has been shown to be most effective in increasing seed yield presumably by destroying weevils when conditions for successful oviposition are most favour-

able. Figs. 4, 5 and 6 present similar graphs for the three other dominant insects collected. In all of them the very temporary residual effects of the DDT is evident. These rapid population build ups must be considered in relation to

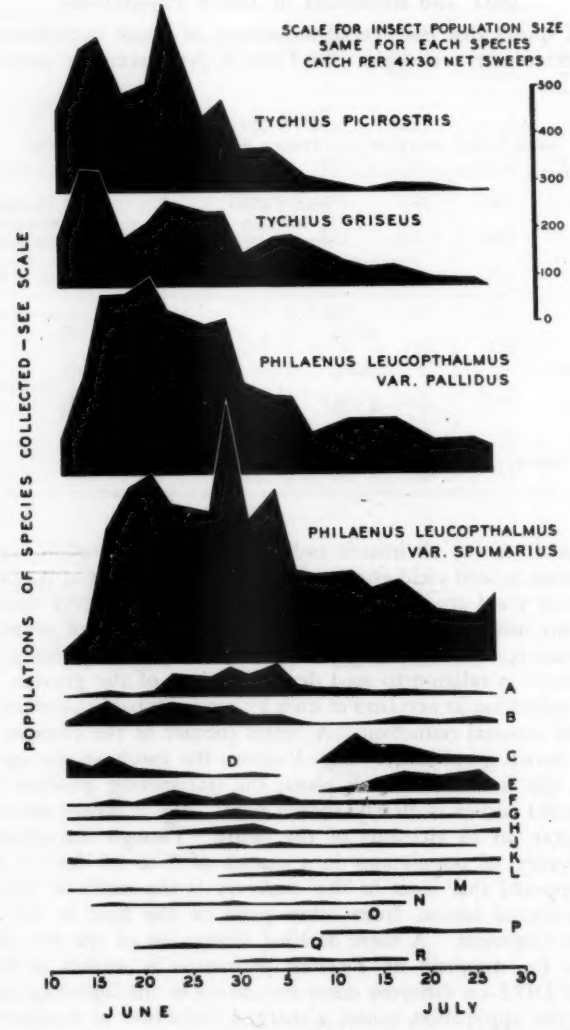


FIG. 1. Seasonal changes in the insect fauna of alsike clover at Cayuga, Haldimand County, 1949. Data from collections on untreated check plots. A, *Lygus pratensis* L. B, *Zenoborus commissuralis* Reuter. C, *Oliarus humilis* Say. D, *Miris dolobratus* (L.). E, *Systena frontalis* F. F, *Philaenus leucopthalmus* L. var. *marginellus*. G, *Nabis ferus* L. H, *Mesogramma marginata* Say. J, *Euschistus variolarus* P. de B. K, *Adelphocoris rapidus* (Say). L, *Campylenchia latipes* (Say). M, *Coccinella perplexa*. N, *Hypera meles* F. O, *Hypera nigrirostris* (F.). P, *Cosmopepla carnifex*, F. Q, *Nabis subcoleopteris* Kirby. R, *Hippodamia parenthesis* Say.

the actual residue of insecticide left on the vegetation. No residue data are available for Cayuga but we have already recorded figures for Brampton (Tables VII and VIII). At Brampton, since the stand of alsike was practically uncontaminated with red clover, almost no *T. griseus* were collected and the 1949 fauna differed noticeably from that at Cayuga, in an absence of spittlebugs. *T. picirostris* alone dominated the fauna. In Fig. 7 the populations of this weevil on the check plots and those plots sprayed June 13 is shown. The shape of

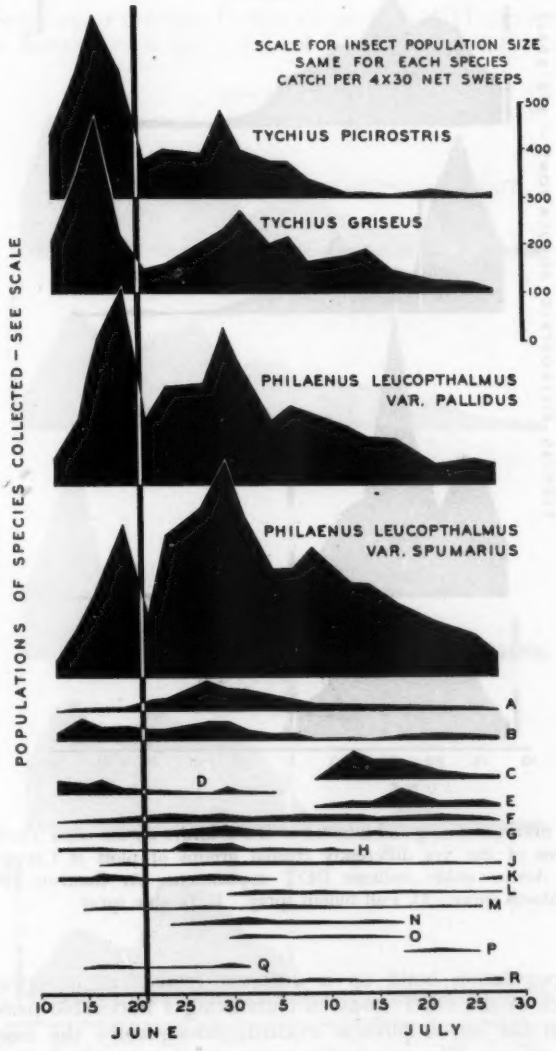


FIG. 2. Seasonal changes in the insect fauna of alsike clover at Cayuga, Haldimand County, 1949, as affected by DDT spraying indicated by arrow stake. Data from collections on plots sprayed June 21. Index letter to species same as in Fig. 1.

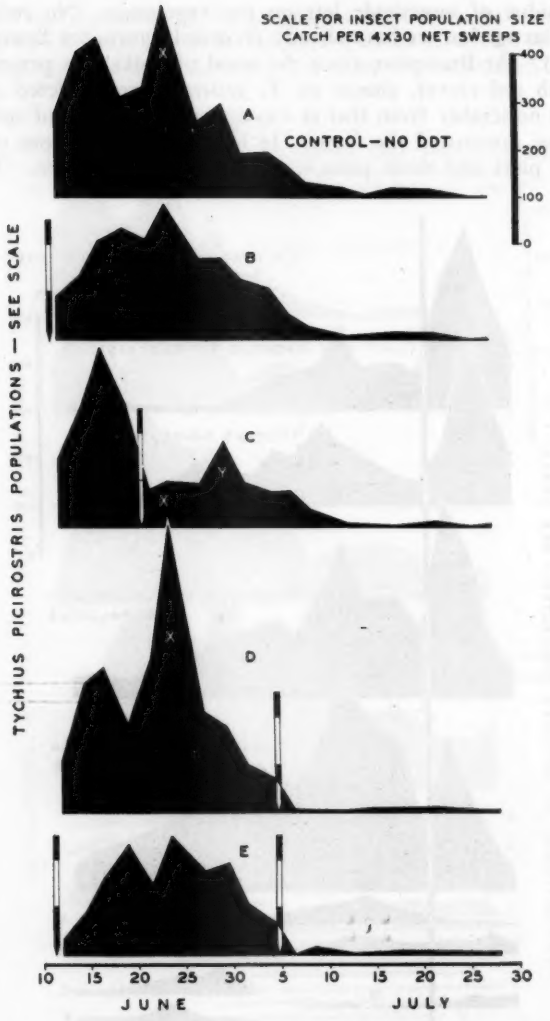


FIG. 3. Effect of different timing and number of DDT sprays on the adult *Tychius picirostris* populations of the five differently treated groups of plots at Cayuga, Haldimand County. Arrow stakes indicate DDT applications. A, Controls. B, Bud spray. C, Half bloom spray. D, Full bloom spray. E, Double spray.

the curve of population build up is different from that at Cayuga but the temporary effect of the DDT spray in eliminating a noticeable peak occurring 5 days later on the check plots is evident; subsequently the insecticide has obviously little effect. The population increase following the June 13 spraying should be read in conjunction with the figures for DDT residue graphed above them. Since, in a period of 7-10 days following spraying, *T. picirostris* numbers have equalled those on check plots it would seem that any remaining insecticide

had little toxic or repellent effect. In this period DDT, in fact, has decreased to about one-quarter (i.e. about 8 mg. per sq. yard or 40 parts per million of alsike) of what it was on the day after spraying. This is a considerable residue which could not be tolerated in any stock feed. However, this residue has not prevented a complete recovery of insect populations. In view of the short lived effect of the DDT under the field conditions tested the importance of correct timing is apparent again.

**Summary**

1. The spraying or dusting of alsike clover with DDT increases seed yield. In 1948 when harvests were good (over 3 bushels per acre) increases ranged

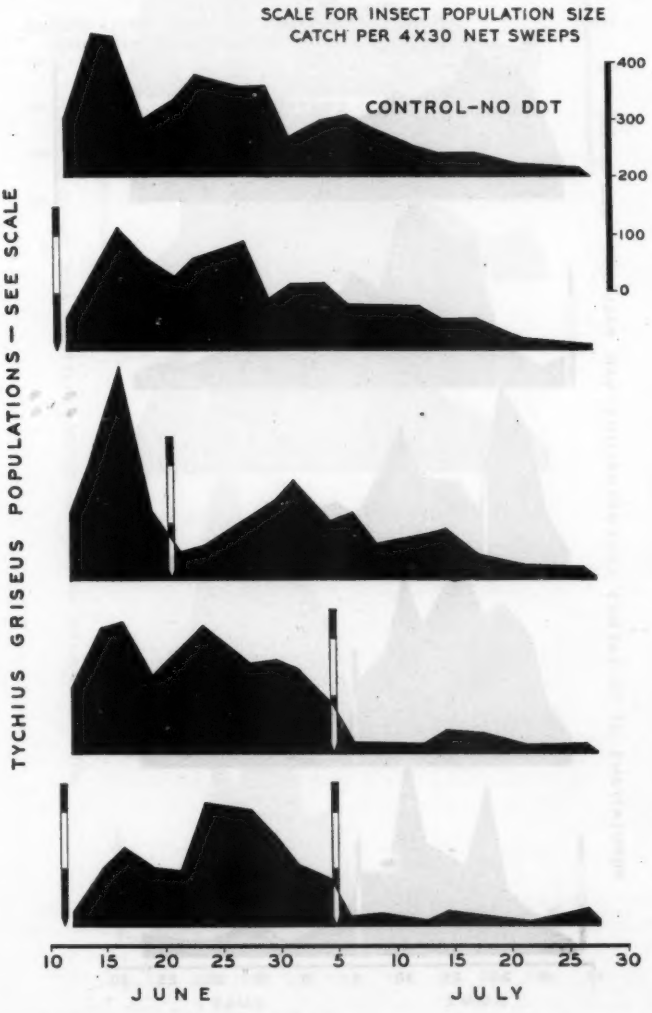


FIG. 4. Effect of the various DDT applications on the *Tychius griseus* populations of the red clover mixed in the stand of alsike, Cayuga, Haldimand County.

from 50 per cent to 100 per cent as they did also in 1949 when harvests were poor (one-fifth of a bushel per acre). DDT applications are then, only of value in years like the former and will not themselves ensure a bumper crop.

2. DDT applications were most effective if applied in the bud stage before appreciable blossom had appeared. The insecticide should be applied at the rate of 1 lb. actual DDT per acre.

3. If operations are delayed until some blossom has appeared the applications should be made when pollinators are not working the flowers. There appear no advantages in using benzene hexachloride or parathion which are more toxic to bees.

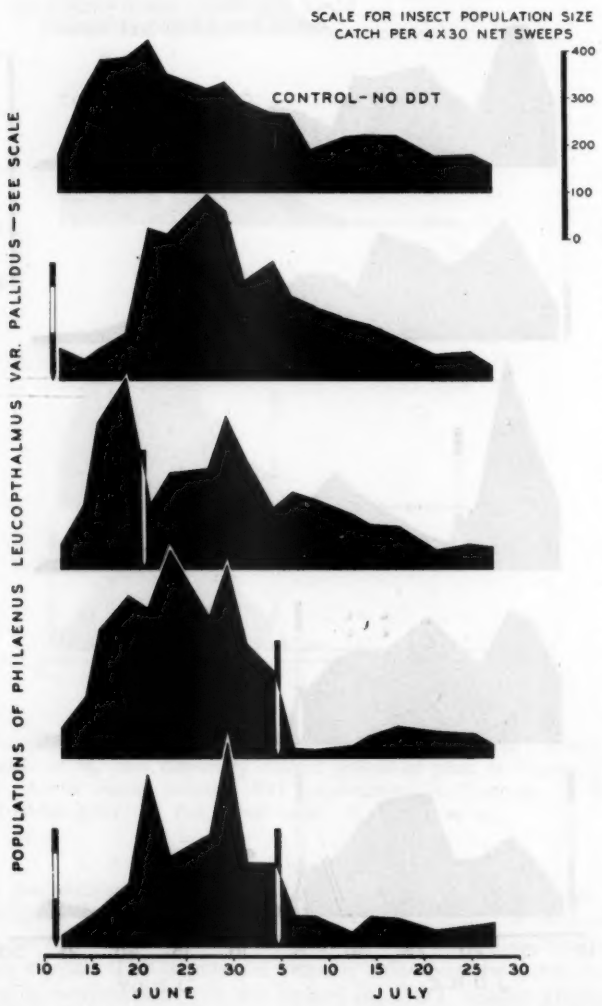


FIG. 5. Effect of the various DDT applications on populations of adult spittlebug, *Philaenus leucopthalmus* L. var. *pallidus*, Cayuga, Haldimand County.

4. The results of extensive insect collections throughout the season, on the various experimental plots, are described. In the areas studied *Tychius picirostris* was universally present and probably the main source of seed destruction. Two

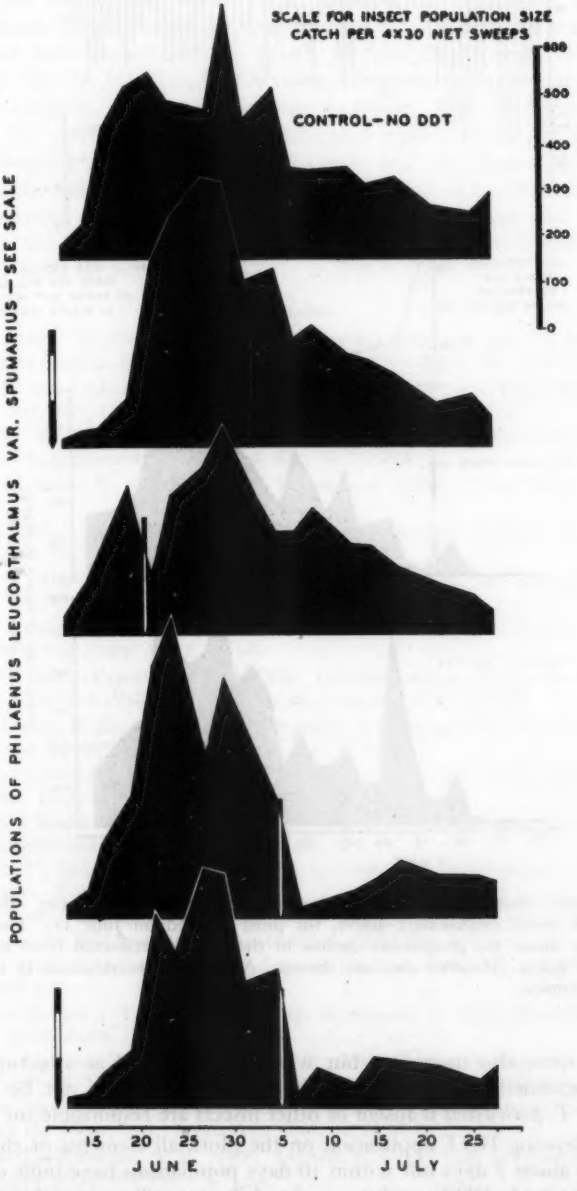


FIG. 6. Effect of the various DDT applications on populations of the adult spittlebug, *Philaenus leucopthalmus* L. var. *spumarius*, Cayuga, Haldimand County.

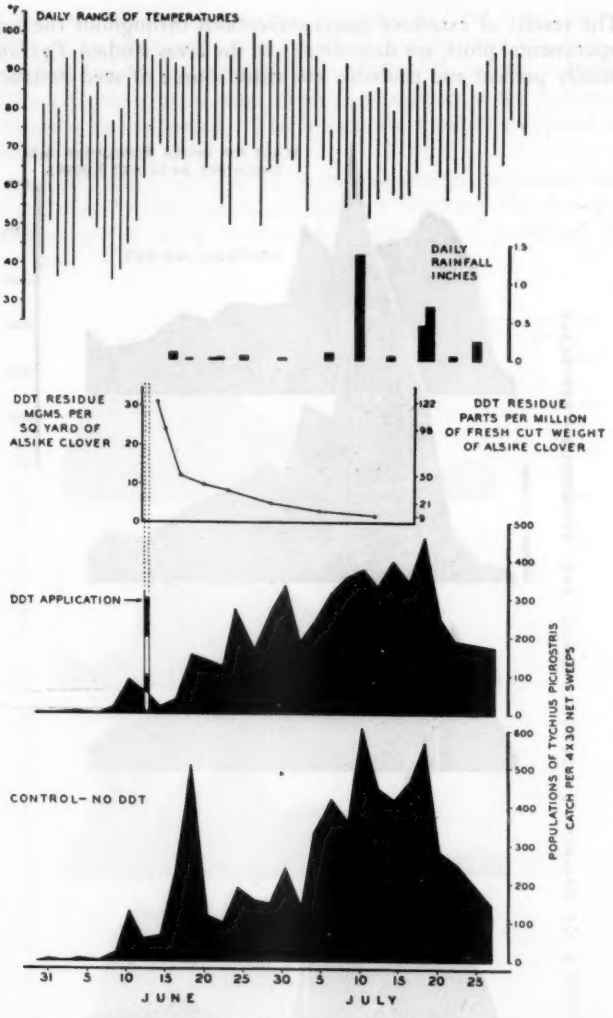


FIG. 7. Seasonal changes in *Tychius picirostris* populations at Brampton. Bottom, data for check plots; immediately above, for plots sprayed on June 13. The DDT residue curve shows the progressive decline of the deposit recovered from the alsike of the latter plots. Weather data are shown. All graphs are referable to the date line at the bottom.

spittlebugs were also numerous but were not identified as affecting seed yield. The recommendation on insecticide treatment above may not be applicable in areas where *T. picirostris* is absent or other insects are responsible for seed damage.

5. Following DDT application on the plots, all elements of the fauna were reduced for about 5 days but within 10 days populations have built up again. At this time detectable DDT residues on the alsike are still appreciable, having fallen to about one quarter the value obtained on the day following application.

**Acknowledgments**

It is impossible to acknowledge all those who have assisted this work but I wish to thank especially my colleagues on the Legume Research Committee of Ontario; particularly Professor J. D. MacLachlan, Chairman of the Committee and Professor A. W. Baker, who answered all requests for equipment and labour, Mr. R. Fulkerson, Field Husbandry Department, who supervised the taking of seed yields and their analysis, Mr. J. Smith, Physics Department, for meteorological records, Dr. D. MacDougal, Chemistry Department who carried out the DDT residue analyses, and my fellow entomologists, Mr. D. Arnott and Mr. Morris Smith, for varied assistance. In addition, I wish to thank Mr. G. Skinner, Agricultural Representative, Haldimand County, and Mr. Bruce Mehlanbacher for locating alsike fields and other invaluable assistance. Last, but not least, the six student assistants who worked on the project throughout the summers—R. H. Burrage and O. T. Page in 1948 and J. C. Fisher, L. H. McMullen, D. J. Mountjoy and J. R. Richards in 1949.

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## Specific Characters in Tarsal Claws of Some Species of *Aedes* (Diptera: Culicidae)[1]

*By* J. R. VOCKEROTH
Ottawa, Canada

Certain species of *Aedes* occurring in North America have been considered difficult if not impossible to identify from adult females alone. Five band-legged species, *Aedes excrucians* (Walker), *A. stimulans* (Walker), *A. fitchii* (F. & Y.), *A. riparius* D. & K., and *A. increpitus* Dyar, are in this class. They form a compact group, and female specimens have been very difficult to identify with assurance. Matheson (1944) used mesonotal colour and mesepimeral bristling for separating most specimens of these species. To these characters Gjullin (1946) added the colour of the torus and of the palp, but he also was unable to definitely identify some specimens of *excrucians* and *fitchii*. Ross (1947) used the characters employed by Matheson to separate *stimulans*, *fitchii*, and *excrucians*, but admitted that the characters are often unsatisfactory.

While comparing female specimens of *excrucians* and *fitchii*, the writer was surprised to note a very distinct difference in the shape of the tarsal claws of the two species. A review of the literature on the five species of this band-legged group showed that the value of specific characters in the tarsal claws had been realized before, but apparently only once and then rather vaguely. Grossbeck (1904), in his description of *Culex siphonalis* [=*A. excrucians* (Walker)][2], said that the species differed from *C. cantans* [=*A. stimulans* (Walker)][3] in the much more slender tarsal claws. However, although Giles (1902) and Blanchard (1905), in their works on world mosquitoes, figured the tarsal claws of many species, and Dyar and other authors used the presence or absence of teeth on the claws to divide the American species of *Aedes* into groups, the value of such characters in separating closely related species seems to have gone almost unappreciated.

The material upon which the following conclusions are based is in the Canadian National Collection at Ottawa. Most of it was collected by personnel

[1]Contribution No. 2710, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.
[2]Synonymy from Dyar (1928).
[3]Synonymy from Howard, Dyar, Knab (1917).

employed in the Northern Insect Survey, sponsored by the Department of Agriculture and the Department of National Defence. Almost all the specimens were individually reared from larvae, and therefore their identity is assured. Only the two male specimens of *increpitus*, the male specimen of *stimulans*, and the whole series of *riparius* were wild-caught; as the females of the latter species were taken at the same place and on the same day as the males, their identity is almost certain. The collection localities and the numbers of specimens examined were as follows:—

*A. excrucians*
- Reindeer Depot, Mackenzie Delta, N.W.T. — 4 ♀ ♀
- Norman Wells, N.W.T. — 1 ♂, 3 ♀ ♀
- Churchill, Man. — 6 ♂ ♂, 36 ♀ ♀
- Great Whale River, Que. — 11 ♂ ♂, 20 ♀ ♀
- Gander, Nfld. — 4 ♂ ♂, 5 ♀ ♀

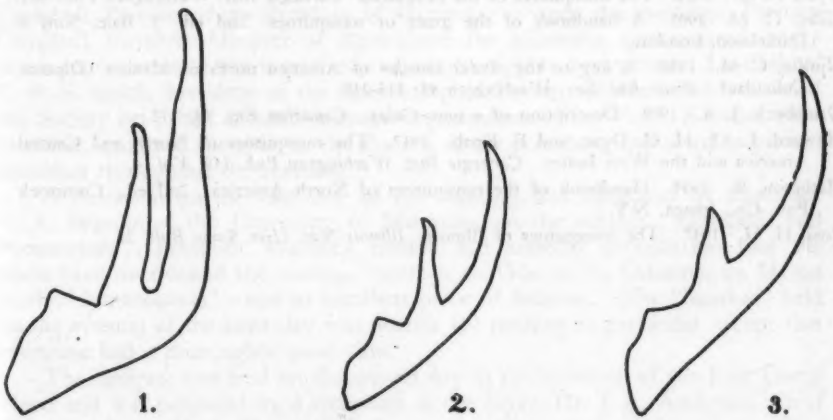
*A. fitchii*
- Norman Wells, N.W.T. — 2 ♂ ♂, 14 ♀ ♀
- Moose Factory, Ont. — 6 ♀ ♀
- Gander, Nfld. — 1 ♂

*A. stimulans*
- Moose Factory, Ont. — 4 ♀ ♀
- Strathroy, Ont. — 1 ♂

*A. riparius*
- Warroad, Minn. — 9 ♂ ♂, 7 ♀ ♀

*A. increpitus*
- Oliver, B.C. — 1 ♂
- River Heights, Utah — 1 ♂

The claws may be examined in the pinned material, or a temporary mount may be made by placing the last tarsal segment in water or glycerine on a slide and pressing it flat with a cover glass, or a permanent mount may be made in a similar manner with balsam or diaphane. The first method is usually satisfactory for identification of specimens; slide mounts are more convenient for careful comparison of the claws of different species or for preparation of drawings.




Fore-tarsal claws:—
1. *Aedes excrucians* (Walker), ♀
2. *Aedes fitchii* (F. & Y.), ♀
3. *Aedes riparius* D. & K., ♀

In the four species of which material of both sexes was available, the following observations were made:—

1. All tarsal claws of females of a species are of the same shape; the claws of the three pairs of tarsi differ only in size.

2. The fore- and mid-tarsal claws of males are greatly modified, but the claws of the hind tarsi are of the same shape as those of the females of the same species.

3. The females of *excrucians* and *riparius* may be distinguished from one another and from those of *fitchii* and *stimulans* by the shape of the tarsal claws; the claws of females of *fitchii* and *stimulans* appear to be indistinguishable.

The fore-tarsal claws of females of *excrucians, fitchii,* and *riparius* are shown in the accompanying figure. The female of *excrucians* has the main claw and the tooth very long and parallel for their whole length, and the main claw is slightly but distinctly sinuate before the tip. The claw of *fitchii* has the main claw extending farther beyond the tooth and parallel with the tooth only at its distal end. The claw of *riparius* has the tooth shorter than that of *fitchii,* and the main claw extends even farther before it turns distinctly upward.

As the two males of *increpitus* have the hind-tarsal claws indistinguishable from those of *fitchii,* it is very likely that females of the two species would have claws of the same shape, i.e., the claws of females of *fitchii, stimulans* and *increpitus* would be indistinguishable from one another.

The wide geographical range of the specimens of *excrucians* and *fitchii,* with no accompanying variation in the form of the tarsal claws, indicates that the character is constant.

A preliminary examination has indicated that tarsal claws may prove valuable in separating closely related species in other groups of *Aedes,* including some of the northern dark-legged forms. The value of a character that remains unaltered in rubbed specimens is, of course, obvious.

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## The Eighty-sixth Annual Meeting

The eighty-sixth annual meeting may claim an important place in the history of the Society. For the first time, the Society met in Western Canada; there was a record registration of delegates from British Columbia to the Maritimes; and a new form of scientific program met with general approval. The position of the Society as the "interim" national organization was strengthened by affiliation of the Entomological Society of Manitoba and a society to be formed in the Maritimes. Certain decisions on furthering the objective of a national organization were made.

This note is intended to record the highlights of the meeting.

The meeting was held at Winnipeg, November 3-5 on the invitation of the Entomological Society of Manitoba. The Manitoba Society undertook to organize the scientific and social programs and to make the arrangements for accommodating the meetings at the Fort Garry Hotel and The University of Manitoba. One hundred and eighty-six delegates were registered.

### The Scientific Program

The scientific program extended the trend away from short reports on current work, towards discussions covering wide areas of entomological interest. This trend was initiated at the eighty-fifth annual meeting at Montreal and extended to its reasonable conclusion at the Winnipeg meeting. Two and one-half days of the meeting were devoted to invitation papers, symposia, and exhibits; one half-day was allotted to the reading of short papers. Yet the device of simultaneous sessions permitted the normal number of short papers to be presented.

The full program, excepting the titles of short papers, was published in *The Canadian Entomologist*, Vol. 81, No. 7, pp. 182-184, 1949. The program comprised 6 invitation papers, 3 symposia, 26 short papers, and 14 exhibits or demonstrations. The scope of the subjects and the calibre of the contributions gave an excellent picture of the maturity of Canadian entomological research. Approval of the form and content of the program was recorded by the Resolutions Committee which commented, "outstanding in the history of the Society".

### The Social Program

The Society was honoured by the presence of the Honourable D. L. Campbell, Premier of the Province of Manitoba, to open the meeting. Premier Campbell, formerly Minister of Agriculture for Manitoba, spoke convincingly of his appreciation of the importance of entomology to agriculture. Lt.-Colonel C. A. S. Smith, President of the Entomological Society of Manitoba welcomed the Society on behalf of the Manitoba organization. Mr. W. N. Keenan, vice-president, accepted the chair in the absence of the president, and acted as general chairman throughout the meeting.

A luncheon on the first day of the meeting was addressed by Professor R. A. Wardle of the University of Manitoba, on the subject, "Hexapods and Hexameters". Professor Wardle's erudite and amusing protestation that the poets have overlooked the insects—"there is no Ode to the Odonata, no Hymn to the Hymenoptera"—was an excellent piece of humour. The "Smoker" held on the evening of the same day was notable for nothing in particular except that everyone had a thoroughly good time.

The banquet was held on the second day in the ballroom of the Fort Garry Hotel and was preceded by a reception in the foyer. Dr. J. A. Anderson, Chief Chemist of the Grain Research Laboratory, addressed the banquet on, "The Scientific Method". Dr. Anderson's brilliant development of the philosophic ideas underlying scientific operations was, without qualification, the outstanding event of the meeting.

**The Business Meetings**

The general business meeting and the meetings of Directors and Council were dominated by discussions relating to the formation of a national society. All that can be done here is to attempt to record the general tenor of these discussions and the more important decisions.

As an objective, the proposal for a national society appeared to have almost universal support, and there was general disappointment that it failed to achieve reality at this meeting. The principal obstacle is the possible inability of the Society to meet its operating costs, mainly the publication of *The Canadian Entomologist*. In the face of this obstacle, the counsel of caution prevailed on the grounds that a national society may not be able, at present, to support the journal.

But the idea of a national organization has become firmly entrenched and there was no question of abandoning it. In effect, the Society assumed the role of an interim national society committed to take certain steps towards the early realization of a national organization in fact. The only visible means for increasing revenue is to increase the membership. It was estimated that there are about 200 entomologists in Canada who do not now subscribe to *The Canadian Entomologist*. If a substantial proportion of these were to become subscribers, there would be no question of financial support for a national society. It was decided therefore to initiate a drive for new subscribers.

Equally important was the decision of the Directors to explore the possibility of retaining present revenues available to the Entomological Society of Ontario in the event of nationalization. The Committee appointed by the Directors was also instructed to study the present policy and organization relating to the Society's library with a view to providing greater service to the members.

The editor of *The Canadian Entomologist* was commended on the improvements made in printing and format of the journal. The journal is attracting more papers on the biology and control of insects than in the past. In reply to the criticism that the journal still fails to reflect the preoccupation of most Canadian entomologists with applied entomology, the editor stated that he can only print what he receives. A shortage of manuscripts makes it necessary to utilize most papers submitted. The position is therefore, that the Society, at considerable expense, has greatly improved the journal as a vehicle for publishing the work of Canadian entomologists; it will reflect the scope and high standard of Canadian entomological research only when authors support it with their best work.

The Society's concern with further improvement of *The Canadian Entomologist* promoted discussion on proposals for revising the editorial policy, appointment of an editorial board, and the drafting of instructions to authors. Action on the appointment of an editorial board was deferred and it was agreed that in the meantime Dr. Thompson's contribution to the symposium, "The Preparation of Scientific Papers", provides adequate instructions to authors, and will be published in the journal.

The annual meeting for 1950 will be held at Guelph. One might predict from the atmosphere of the Winnipeg meeting that Guelph, birthplace of The Entomological Society of Ontario, will see the birth of The Entomological Society of Canada.

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